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(54) **ASPIRATION CASSETTE WITH GAS AND DEBRIS MANAGEMENT**

(71) Applicants: **Shawn X. Gao**, Irvine, CA (US); **Roderick S. Van**, Long Beach, CA (US)

(72) Inventors: **Shawn X. Gao**, Irvine, CA (US); **Roderick S. Van**, Long Beach, CA (US)

(73) Assignee: **Alcon Research, Ltd.**, Fort Worth, TX (US)

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A61F 9/007 (2006.01)

(52) **U.S. Cl.**

CPC ***A61F 9/00736*** (2013.01); ***A61M 1/0058*** (2013.01); *A61M 2205/123* (2013.01); *A61M 2205/3306* (2013.01); *A61M 2205/3389* (2013.01); *A61M 2210/0612* (2013.01)

(58) **Field of Classification Search**

CPC A61F 9/00736; A61M 2205/12; A61M 2205/123

USPC 604/319, 9, 326, 541–542

See application file for complete search history.

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Primary Examiner — Philip R Wiest
Assistant Examiner — Ariana Zimbouski

(57) **ABSTRACT**

Embodiments of this disclosure provide an apparatus and method for gas and debris management. The apparatus comprises a surgical cassette, wherein the surgical cassette is at least partially formed of a cassette material defining a chamber. The surgical cassette has a floor and a plurality of walls. The apparatus also has a drain conduit with a drain entry and a drain exit. The drain entry is connected to the chamber near the floor. The drain conduit has a top portion and a bottom portion. The apparatus also has an aspiration conduit. The aspiration conduit has an aspiration port and an aspiration exit. The aspiration conduit is in liquid communication with the chamber and the drain conduit. At least a portion of the top portion of the drain conduit is positioned above at least a portion of the aspiration exit.

5 Claims, 7 Drawing Sheets

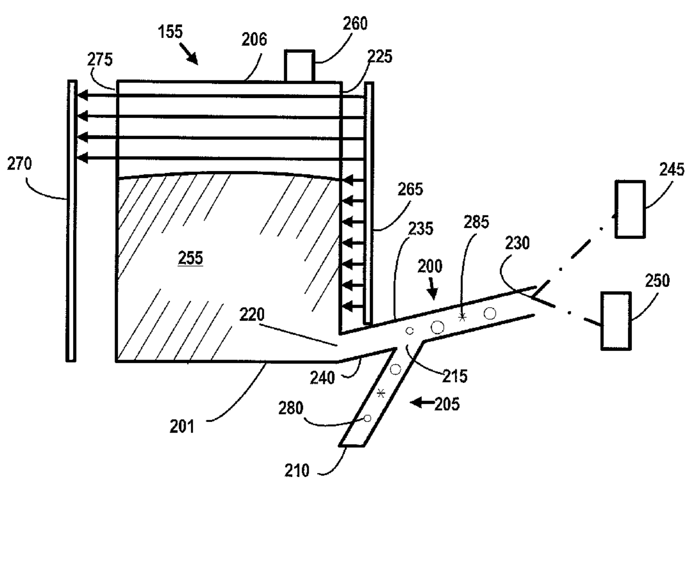

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FIG. 1

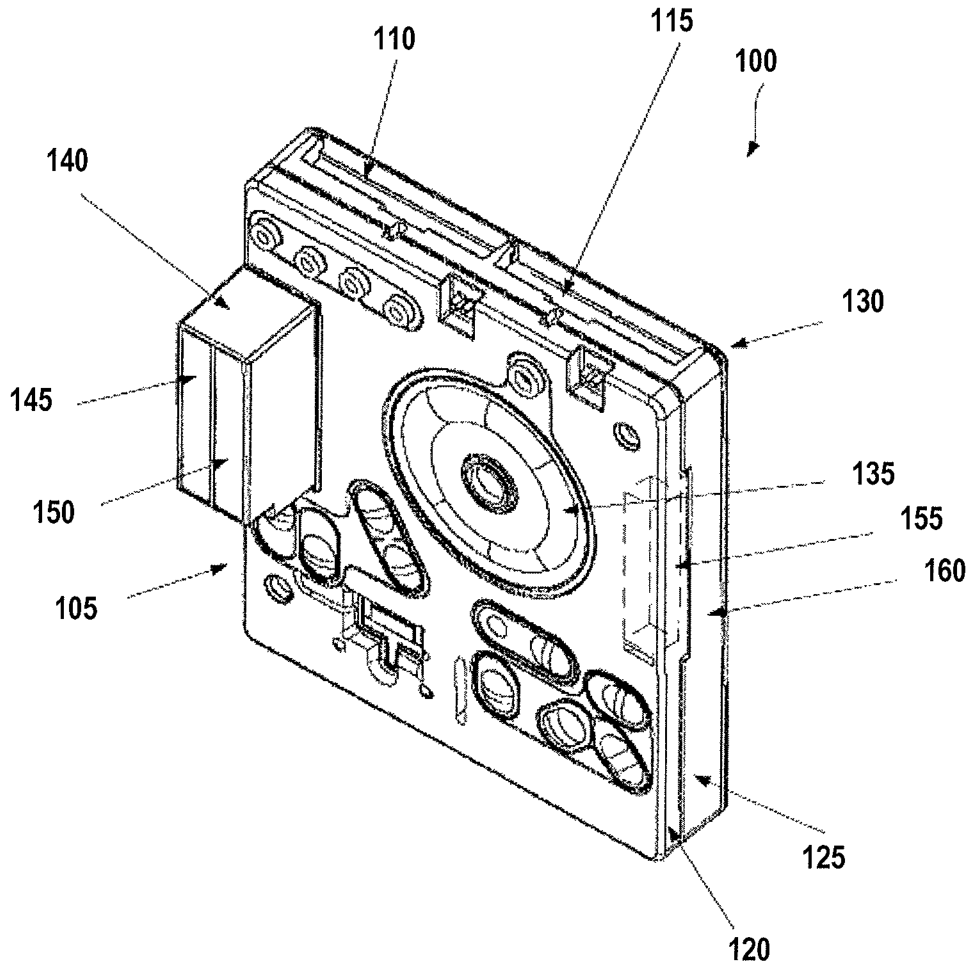


FIG. 2

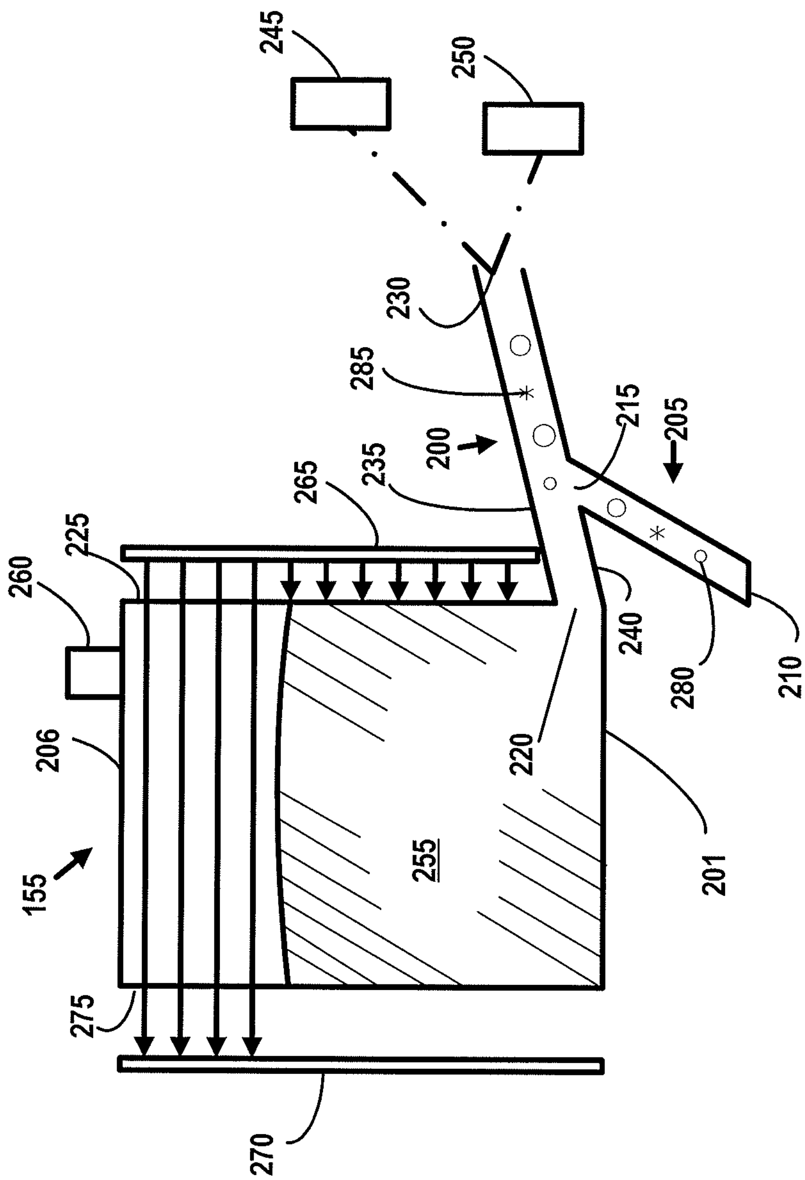

245
250
230
285
200
235
265
225
260
215
205
240
220
210
280
206
155
255
201
275
270

FIG. 3A

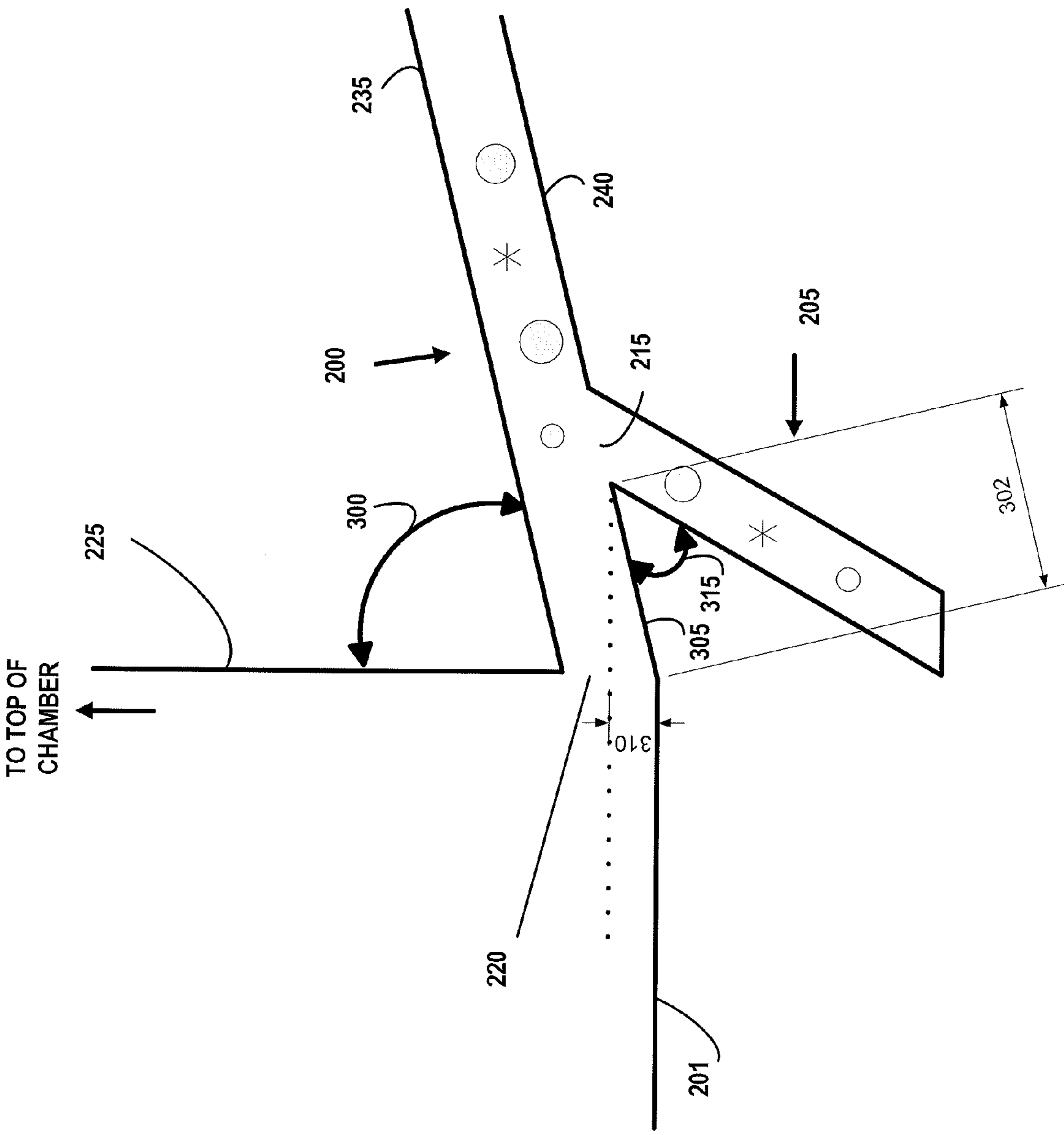

235
240
200
215
205
300
302
225
315
305
310
TO TOP OF CHAMBER
220
201

FIG. 3B

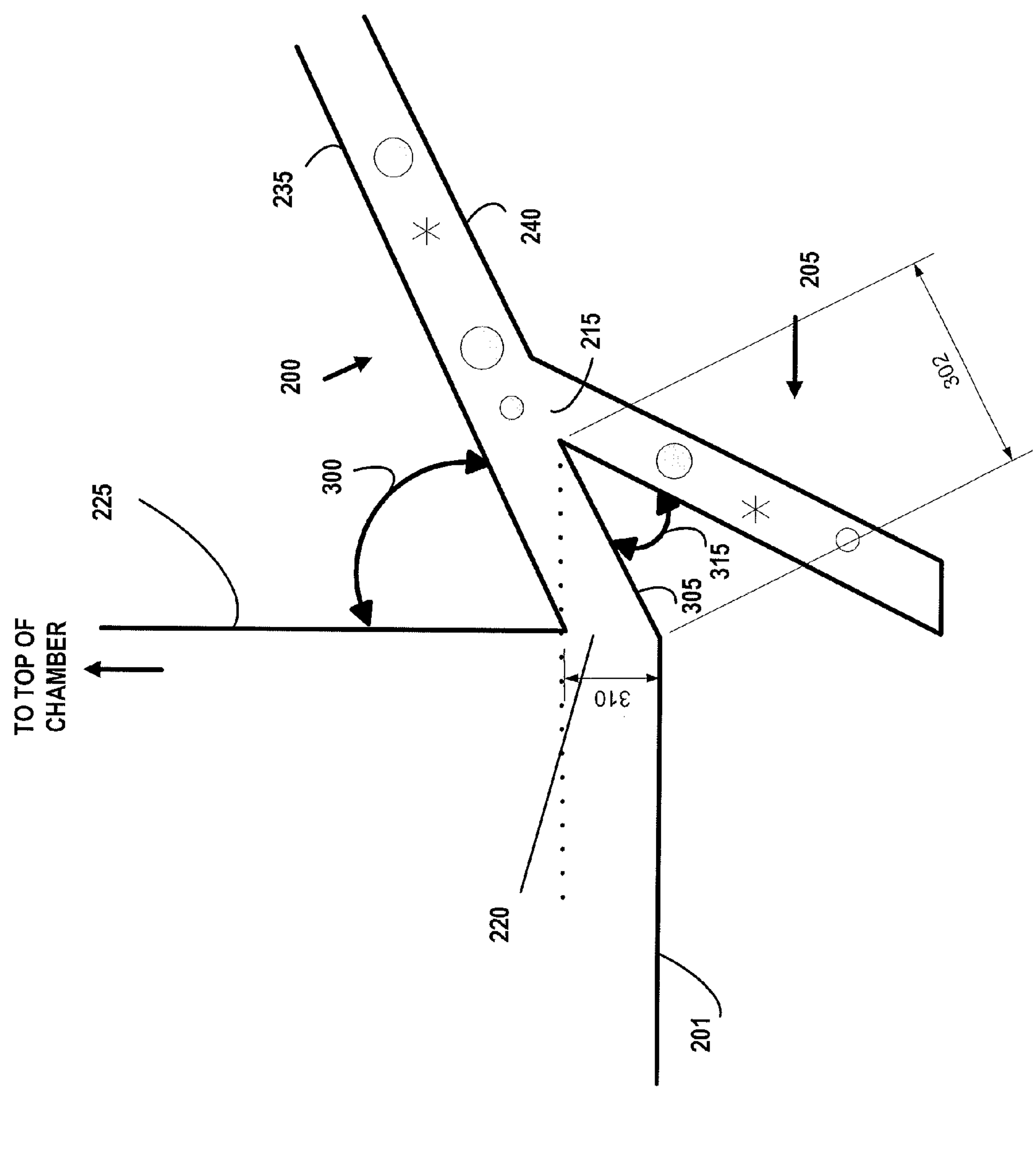

225
300
200
235
240
205
215
302
315
305
310
220
201
TO TOP OF CHAMBER

FIG. 4

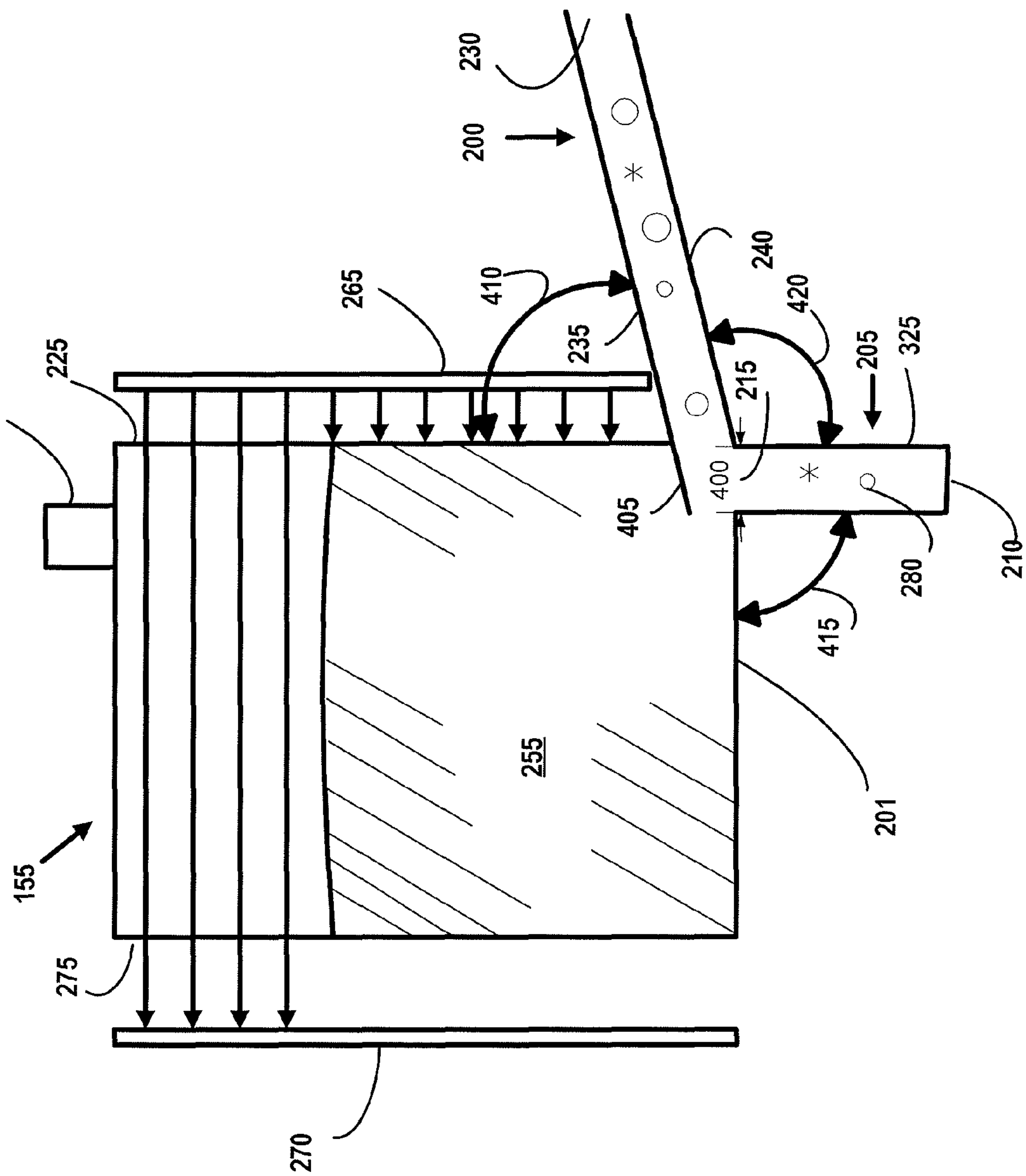

230
200
240
265
410
420
235
225
205
325
260
215
400
405
280
210
415
255
201
155
275
270

FIG. 5

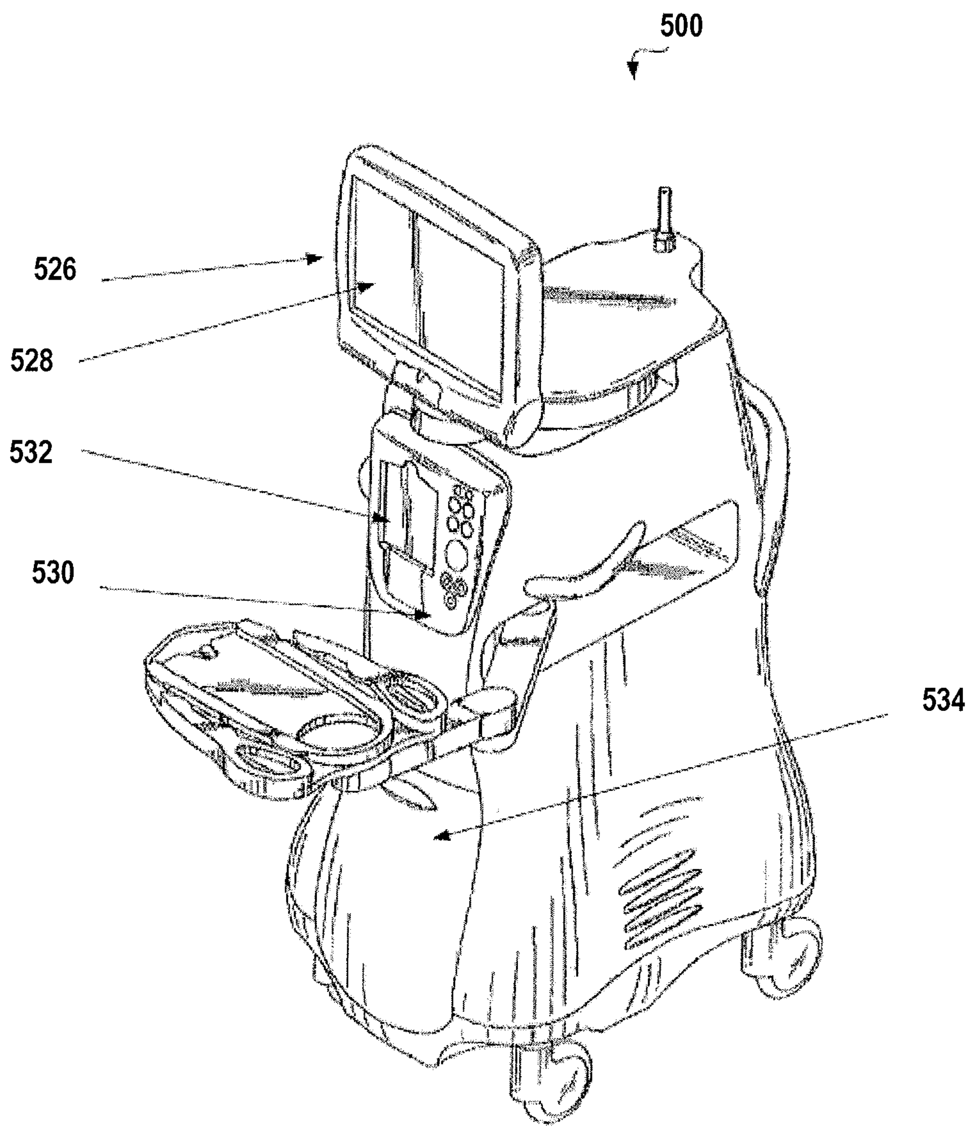
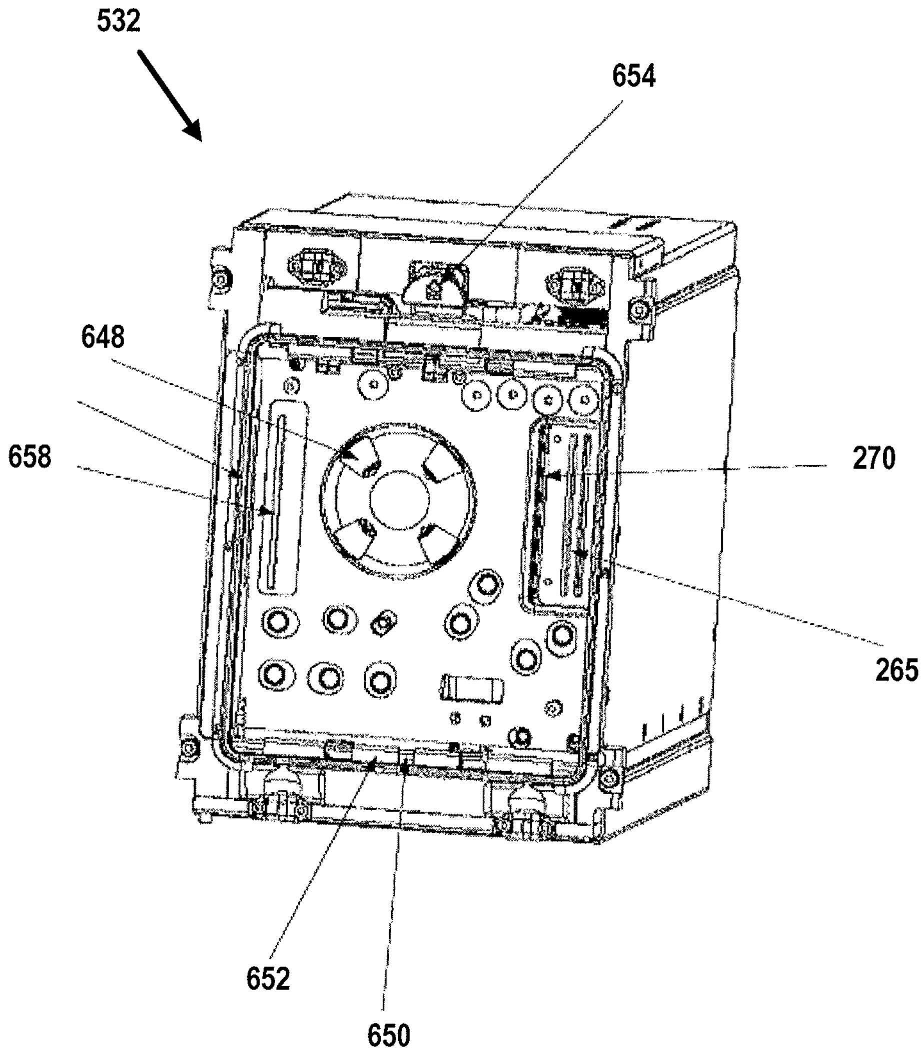


FIG. 6



ASPIRATION CASSETTE WITH GAS AND DEBRIS MANAGEMENT

BACKGROUND

During small incision surgery, and particularly during ophthalmic surgery, small probes are inserted into the operative site to cut, remove, or otherwise manipulate tissue. During these surgical procedures, fluid is typically infused into the eye, and the infusion fluid and tissue are aspirated from the surgical site. The aspirated fluids from the surgical site are at least partially drawn into an aspiration chamber located within a surgical cassette. The level of aspirated fluids in the aspiration chamber is measured using a non-invasive level sensor. In prior systems, gas and debris in the aspirated fluids enter the aspiration chamber, which results in the level sensor producing inaccurate readings. This can cause certain problems. Therefore, a need continues to exist for an improved aspiration cassette with gas and debris management.

SUMMARY

The present disclosure relates in general to an apparatus having an aspiration cassette with gas and debris management and more particularly to an aspiration cassette for an ophthalmic microsurgical system that prevents gas or debris within aspiration liquid from entering an aspiration chamber of the aspiration cassette. In one embodiment, an apparatus has a chamber having a floor and a plurality of walls. The apparatus also has a drain conduit, the drain conduit having a drain entry and a drain exit, wherein the drain entry is connected to the chamber near the floor. The drain conduit also has a top portion and a bottom portion. The apparatus also has an aspiration conduit in liquid communication with the chamber and the drain conduit, wherein the aspiration conduit has an aspiration port and an aspiration exit, and wherein at least a top portion of the drain conduit is positioned above at least a portion of the aspiration exit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic representation of one embodiment of a liquid cassette;

FIG. **2** is a diagrammatic representation of an aspiration chamber configuration within the liquid cassette of FIG. **1**, according to an exemplary embodiment;

FIG. **3**A is an enlarged portion of the diagrammatic representation of FIG. **2**, according to an exemplary embodiment;

FIG. **3**B is an enlarged portion of the diagrammatic representation of FIG. **2**, according to an exemplary embodiment;

FIG. **4** is another diagrammatic representation of an aspiration chamber configuration within the liquid cassette of FIG. **1**, according to an exemplary embodiment.

FIG. **5** is a diagrammatic representation of one embodiment of a surgical console; and,

FIG. **6** is a diagrammatic representation of one embodiment of a cassette receiver.

DETAILED DESCRIPTION

The following disclosure provides many different embodiments or examples. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

In an exemplary embodiment, as illustrated in FIG. **1**, a diagrammatic representation of a liquid cassette is generally referred by the reference numeral **100**. The cassette **100** can provide a closed system fluidic device that can be discarded following a surgical procedure. A surgical procedure is generally performed on a human body and typically involves forming a passage through an external surface of the body, but can also be performed through a natural orifice. The cassette **100** can include a cassette body **105** and portions that interface with a clamp (e.g., indicated generally at clamping zones **110** and **115**) projecting from the cassette body **105**. The cassette **100** can be formed of ABS plastic or other suitable material. In the embodiment shown, the cassette **100** is formed from three primary sections: an inner or surgical console interface section **120** that faces an ophthalmic surgical console **500** (shown in FIG. **5**) when the cassette **100** is inserted into the ophthalmic surgical console, a middle section **125**, and a cover plate **130**. The various sections of the cassette **100** can be coupled together via a press fit, interlocking tabs, chemical bonding, thermal bonding, mechanical fasteners or other attachment mechanism known in the art. In other embodiments, the cassette **100** can be formed of a single piece or multiple pieces.

The surgical console interface section **120** can face the console **500** during use and provide an interface for liquid flow channels (e.g., flow channel **135** for the peristaltic pump provided by an elastomeric pump membrane), valves (e.g., infusion/aspiration valves), and other features to manage liquid flow. The cassette **100** can also attach to a drain bag (not shown) to collect liquids during a procedure.

In one embodiment, the liquid cassette **100** is formed of a cassette material formed to create chambers to hold liquids for aspiration and infusion. For example, chamber cartridge **140** can include two infusion chambers **145** and **150**. An aspiration chamber **155** can be internal to the cassette **100** on the opposite side of the cassette **100** from the chamber cartridge **140** (e.g., at the side of cassette **100** indicated by **160**). According to one embodiment, the level of liquid in the chambers can be determined in a noninvasive manner. As described below, light can be projected into the walls of each of the chambers **145**, **150** and **155** using a vertical light source (not shown). Depending on the reflection or refraction of light at the chambers **145**, **150**, and **155**, a vertical sensor array will detect or not detect light at various points along the array's vertical axis. Based on the transition between illuminated and non illuminated portions of the sensor array, the level of the liquid in each of the chambers **145**, **150**, and **155** can be detected. One embodiment of a non-invasive method of measuring the liquid in the chambers is described in U.S. Pat. No. 7,956,341 to Gao, which is hereby fully incorporated by reference herein.

FIG. **2** is a diagrammatic representation of the chamber **155** having a drain conduit **200** extending from a floor **201** of the chamber **155** and an aspiration conduit **205** coupled thereto. The chamber **155** has a top **206**. The chamber **155** is in liquid communication with the aspiration conduit **205** and the drain conduit **200**. On one end, the aspiration conduit **205** has an aspiration port **210** which can be attached to a surgical device (not shown) used to remove liquid and other matter from a surgical site (not shown). The aspiration conduit **205** has an aspiration exit **215** located at an opposing end. The aspiration exit **215** is fluidly coupled to the chamber **155** and the drain conduit **200**, therefore the aspiration conduit **205** is in liquid communication with the chamber **155** and the drain conduit **200**. The drain conduit **200** has a drain entry **220** that is located on one end portion of the drain conduit **200**, with the drain entry **220** being attached to a chamber wall **225**. A drain exit **230** is located at an opposing end of the drain conduit **200**. The drain conduit **200** also has a top portion **235** and a bottom portion **240**. The drain exit **230** is configured to be attached to a drain bag **245** and coupled to a drain pump **250**, which if activated, can draw a liquid **255** through the aspiration port **210** and towards the drain bag **245**. The chamber **155** is configured to attach to a chamber pump **260**. The level of the liquid **255** in the chamber **155** is measured using a light source **265** and a sensor **270**. In one embodiment, the portions of the wall **225** and a wall **275** that face the light source **265** and the sensor **270** are transparent or opaque. The sensor **270** receives some portion of the light projected by the light source **265** and outputs a signal indicating the amount of light received at various portions of the sensor **270** (e.g., at various pixels of the array). In one embodiment, an edge detection scheme is applied to the output of the sensor **270** to determine which portions of the linear sensor array are sufficiently illuminated to indicate the presence/absence of the liquid **255** at the corresponding level in the chamber **155**. According to one embodiment, the output of different portions of the sensor **270** are compared with a threshold to determine if that portion of the sensor **270** is in a first state (e.g., associated with air) or in a second state (e.g., associated with the liquid). The transition between the first state and second state portions of the linear sensor array marks the level of the liquid **255**. It should be noted however, other edge detection mechanisms can be employed, such as linear interpolation. Introduction of a gas **280** or other matter, such as debris **285**, into the liquid **255** can affect the accuracy of the sensor **270**. Accordingly, preventing the gas **280** or the debris **285** from entering the chamber **155** improves the accuracy of the sensor **270**.

In one embodiment and as shown in FIG. 3A, the drain entry **220** is attached to the chamber **155** with the drain conduit **200** extending upwards from near the floor **201** of the chamber **155**. The intersection of the top portion of the drain conduit **235** and the chamber wall **225** forms a nonorthogonal, acute angle **300** between the top portion of the drain conduit **235** and the chamber wall **225**. Additionally, the aspiration conduit **205** is attached to the drain conduit **200** with the aspiration exit **215** intersecting the bottom portion of the drain conduit **240**. The intersection of the drain conduit **200** and the aspiration conduit **205** is offset from the wall **225** by a first distance **302** along the bottom portion of the drain conduit **240** defining a first portion **305**. The intersection of the drain conduit **200** and the aspiration conduit **205** is offset above the drain entry **220** and towards the top of the chamber **206** by a second distance **310**. That is, the intersection of the drain conduit **200** and the aspiration conduit **205** is located above the floor **201** and towards the top **206** of the chamber **155**. A nonorthogonal, acute angle **315** is defined at the intersection of the first portion **305** and the aspiration conduit **205**. The acute angle **315** is an acute angle to minimize turbulence flow of the liquid **255** towards the chamber **155** at the aspiration exit **215**.

In another embodiment, as shown in FIG. 3B, the acute angle **300** and the first distance **302** along the bottom portion of the drain conduit **240** is such that the second distance **310** is equal to or greater than the height or opening of the drain entry **220**.

In another embodiment, as shown in FIG. 4, the aspiration conduit **205** can be attached to the chamber **155** near the floor **201** of the chamber **155**. The aspiration exit **215** can have an opening **400**. The top portion of the drain conduit **235** extends within the chamber **155** to form an exit cover **405**. The exit cover **405** has a length and at least partially covers the aspiration exit opening **400**. In one embodiment, the length of the exit cover **405** is the same measurement as the aspiration exit opening **400**. In one embodiment, the length of the cover **405** extends over the exit opening **400**. The top portion of the drain conduit **235** intersects the chamber wall **225** to define a non-orthogonal, acute angle **410** between the top portion of the drain conduit **235** and the chamber wall **225**. The aspiration conduit **205** intersects the floor **201** to form an angle **415** between the aspiration conduit **205** and the floor **201**. In one embodiment, the angle **415** is an acute angle to minimize turbulence flow of the liquid **255** towards the chamber **155** at the aspiration exit **215**. In one embodiment, the angle **415** is a right angle. The aspiration conduit **205** intersects the drain conduit **200** to define an obtuse angle **420** between the aspiration conduit **205** and the bottom portion of the drain conduit **240**. The intersection of the aspiration conduit **205** and the bottom portion of the drain conduit **240** is not offset from the floor **201**. The aspiration exit opening **400** is located inside of the chamber **155**. In one embodiment, the aspiration exit opening **400** is at least partially located inside of the chamber **155**.

In an exemplary embodiment, as illustrated in FIG. **5**, the ophthalmic surgical console is generally referred to by the reference numeral **500**. The surgical console **500** can include a swivel monitor **526** that has a touch screen **528**. The swivel monitor **526** can be positioned in a variety of orientations for whomever needs to see the touch screen **528**. The swivel monitor **526** can swing from side to side, as well as rotate and tilt. The touch screen **528** provides a graphical user interface ("GUI") that allows a user to interact with the console **500**.

The surgical console **500** also includes a connection panel **530** used to connect various tools and consumables to the surgical console **500**. The connection panel **530** can include, for example, a coagulation connector, connectors for various hand pieces, and a cassette receiver **532**. The surgical console **500** can also include a variety of user friendly features, such as a foot pedal control (e.g., stored behind panel **534**) and other features.

In operation, the cassette **100** can be placed in the cassette receiver **532**. A clamp in the surgical console **500** clamps the cassette **100** in place to minimize movement of the cassette **100** during use. The clamp can clamp the top and bottom of the cassette **100**, the sides of the cassette **100** or otherwise clamp the cassette **100**.

FIG. **6** is a diagrammatic representation of one embodiment of the cassette receiver **532** without a cassette **100**. The cassette receiver **532** can have various pneumatic input and output ports to interface with the liquid cassette **100**. The cassette receiver **532** can further include an opening to allow peristaltic pump rollers **648** to contact the liquid cassette **100** during operation. One embodiment of a peristaltic pump and complimentary cassette is described in U.S. Pat. No. 6,293,926 to Sorensen, which is hereby fully incorporated by reference herein.

The liquid cassette receiver **532**, in the embodiment of FIG. **6**, is configured to hold the cassette **100** in place by a clamp having a bottom rail **650** and a top rail (not shown). Each rail can have outer clamping fingers (e.g., clamp finger **652**) that contact the cassette **100** in corresponding clamping zones and inner clamping fingers to locate the cassette **100** during insertion and push the cassette **100** out of the cassette receiver **532** during release. A release button **654** is pressed to initiate release of the cassette **100** from the clamp. The cassette receiver **532** can include the linear light source **265** and a linear light source **658**. The linear light source **265** projects light onto the walls of the cassette chamber **155** and the sensor array **270** to detect the light refracted through the chamber wall **225**. Each linear light source **265** can include a plurality of light sources vertically arranged (i.e., to project light along vertically spaced transmission paths) and positioned to project light onto a wall of the chamber **155**. Respective linear sensor arrays can receive light refracted through the chamber or reflected at the chamber surface.

The configuration of FIG. **6** is provided by way of example. The form factor of the cassette receiver **532**, placement and number of input/output ports and other features of the cassette receiver **532** can depend on the surgical console **500**, surgical procedure being performed, or other factors.

In operation, the aspiration conduit **205**, the drain conduit **200**, and the chamber **155** is at least partially filled with the liquid **255**. The chamber pump **260** is activated to draw the liquid **255** from the surgical site through the aspiration port **210**. The drain pump **250** is activated to remove at least some of the liquid **255**. In one embodiment, the drain pump **250** can be activated by the level sensor **270**. The liquid **255** often contains the gas **280** and the debris **285**, which if introduced into the chamber **155**, can result in the sensor **270** producing inaccurate results due to the gas **280** and the debris **285** creating turbulence within the liquid **255**, interfering the level sensing light, or creating bubbles and or foam near a top surface of the liquid **255** within the chamber **155**. The gas **280** and the debris **285** can be introduced into the liquid **255** due to improper surgical technique, un-primed or leaky probes or hand pieces, etc.

In operation and referring to FIGS. **2** and **3**A or **3**B, coupling the aspiration exit **215** to the bottom portion of the drain conduit **240** can reduce the amount of gas **280** and debris **285** introduced into the chamber **155**. When the drain pump **250** is activated, the force on the liquid **255** from the drain pump **250** overcomes the force on the liquid **255** from the chamber pump **260**, therefore, the liquid **255**, along with the gas **280** and debris **285** flows away from the aspiration port **210** and towards the drain bag **245**. Buoyancy forces in the gas **280** will force the gas **280** away from the aspiration port **210** and pull it upwards. Locating the intersection of the aspiration conduit **205** and drain conduit **200** above the drain entry **220** and away from the chamber **155** by a first portion **305** encourages gas **280** and debris **285** to flow upwards with its buoyancy force towards the drain bag **245**. Due to the acute angle **300** and the buoyancy forces in the gas **280**, the gas will naturally flow through the drain conduit **200** towards the drain bag **245** and away from the chamber **155**. The acute angle **315** reduces turbulence within the fluid **255** at the intersection of the aspiration conduit **205** and the drain conduit **200** and directs the flow of the liquid **255** towards the drain bag **245** and away from the chamber **155**. Any gas **280** and debris **285** within the liquid **255** also flows towards the drain bag **245** and away from the chamber **155**.

In operation and referring to FIG. **4**, coupling the aspiration exit **215** to the bottom portion of the drain conduit **240** and the floor **201** can also reduce the amount of gas **280** and debris **285** introduced into the chamber **155**. While the intersection of the aspiration conduit **205** and drain conduit **200** is not located above and away from the chamber floor **201**, due to the acute angle **410** and the buoyancy forces in the gas **280**, the gas will naturally flow through the drain conduit **200** towards the drain bag **245** and away from the chamber **155**. The exit cover **405** directs the gas **280** and debris **285** towards the drain bag **245**.

It is understood that variations may be made in the foregoing without departing from the scope of the present disclosure.

In several exemplary embodiments, the elements and teachings of the various illustrative exemplary embodiments may be combined in whole or in part in some or all of the illustrative exemplary embodiments. In addition, one or more of the elements and teachings of the various illustrative exemplary embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various illustrative embodiments.

Any spatial references such as, for example, "upper," "lower," "above," "below," "between," "bottom," "vertical," "horizontal," "angular," "upwards," "downwards," "side-to-side," "left-to-right," "right-to-left," "top-to-bottom," "bottom-to-top," "top," "bottom," "bottom-up," "top-down," etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.

In several exemplary embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures may also be performed in different orders, simultaneously and/or sequentially. In several exemplary embodiments, the steps, processes and/or procedures may be merged into one or more steps, processes and/or procedures.

In several exemplary embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations may be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.

Although several exemplary embodiments have been described in detail above, the embodiments described are exemplary only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures.

What is claimed is:

1. An apparatus comprising:

a surgical cassette, wherein the surgical cassette is at least partially formed of a cassette material defining a chamber, the chamber having a floor and a plurality of walls;

a drain conduit having a drain entry and a drain exit, the drain entry connected to the chamber near the floor, the drain conduit having a top portion and a bottom portion; and

an aspiration conduit having an aspiration port and an aspiration exit directly exiting into the drain conduit, wherein the aspiration exit is separated from the chamber by the bottom portion of the drain conduit, and wherein the aspiration conduit is in liquid communication with the chamber through the bottom portion of the drain conduit; and

wherein at least a portion of the top portion of the drain conduit is positioned above at least a portion of the aspiration exit; and

wherein the bottom portion of the drain conduit is located below both the aspiration exit and the top portion of the drain conduit;

wherein the apparatus further comprises:

a chamber pump coupled to the chamber for pulling a first vacuum on the chamber; and

a drain pump coupled to the drain exit for pulling a second vacuum on the drain conduit;

wherein fluid from the aspiration conduit flows into the chamber during operation of the chamber pump; and

wherein fluid from the aspiration conduit flows into the drain exit during operation of the drain pump.

2. The apparatus of claim **1**, wherein the aspiration exit intersects the bottom portion of the drain conduit.

3. The apparatus of claim **2**, wherein the intersection of the aspiration exit and the bottom portion of the drain conduit is located outside of the chamber.

4. The apparatus of claim **3**,

wherein the intersection is offset from one of the plurality of walls of the chamber by a first distance;

wherein the aspiration exit is offset above the drain entry by a second distance; and

wherein a non-orthogonal acute angle is formed at the intersection between the bottom portion and the aspiration conduit.

5. The apparatus of claim **1**, wherein the drain conduit extends away from one of the plurality of walls of the chamber to form a non-orthogonal acute angle between the drain conduit and the one of the plurality of walls of the chamber.

* * * * *